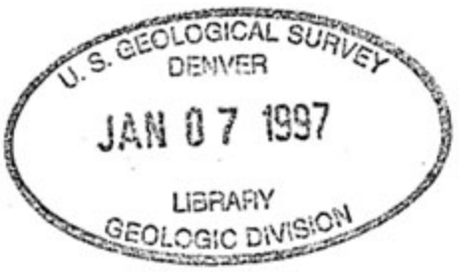
UNITED STATES DEPARTMENT OF INTERIOR

U.S. GEOLOGICAL SURVEY

ESTIMATES OF INFERRED RESERVES FOR THE 1995 USGS NATIONAL OIL AND GAS RESOURCE ASSESSMENT

by

David H. Root, Emil D. Attanasi, Richard F. Mast, and Donald L. Gautier



U. S. Geological Survey Open-File Report 95-75L

This report is preliminary and has not been reviewed for conformity to U.S. Geological Survey editorial standards and stratigraphic nomenclature.

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

United States Department of the Interior

GEOLOGICAL SURVEY

RESTON, VA 22092

Mail Stop 903
December 26, 1996

MEMORANDUM

To: Earth Science Information Center

From: Chief, Office of Scientific Publications

Subject: New USGS open-file report

The following report was authorized by Elmer F. Smith, III for the Director on 12/13/96 for release in the open files:

Project Number: 7330-49022 BETR Number: R97-0161

TITLE: Estimates of inferred reserves for the 1995 USGS National Oil and Gas Resource Assessment

AUTHOR: David H. Root, Emil D. Attanasi, Richard F. Mast, and Donald L. Gautier

CONTENTS: 32 pages, ___ sheets Map Scales: ____
Diskettes:___ CD ROM:__ 3-D Glasses:__ Slides:__ Videos:__

DEPOSITORIES

(NC) USGS Library, Rm 4A100, 12201 Sunrise Valley Dr., Reston, VA 22092
(Da) USGS Library, Rm C2002, Bldg 20, Denver Federal Center, Lakewood, CO 80225
(Mail address: Stop 914, Box 25046, Federal Center, Denver, CO 80225
(M) USGS Library, 345 Middlefield Rd., Menlo Park, CA 94025

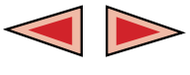
PRICE:
Fiche: $_____
Paper: $_____ Diskette: $20.00

ORIGINATING OFFICE
Name: BETR MS903, Reston,VA
Telephone: (703) 648-4323

Release date: JAN 1997
Area: _____
OFR No. 95-75L

Contents

ILLUSTRATIONS



TABLES

TABLE OF CONVERSIONS TO SI UNITS

multiply unit	by	to obtain metric unit
barrel	0.159	cubic meter
cubic foot	0.02832	cubic meter
foot	0.3048	meter

UNIT ABBREVIATIONS

BBO ....Billions of barrels of oil

BBL ....Billions of barrels

TCF ....Trillions cubic feet

MMBO....Millions of barrels of oil

ESTIMATES OF INFERRED RESERVES FOR THE 1995 USGS NATIONAL OIL AND GAS RESOURCE ASSESSMENT

by
David H. Root, Emil D. Attanasi, Richard F. Mast, and Donald L. Gautier

Abstract

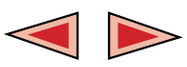
This report describes the data, methods, and national and regional estimates of inferred reserves from the 1995 U. S. Geological Survey's National Assessment of Oil and Gas Resources. Over the next 80 years, about 60 billion barrels of oil and 322 trillion cubic feet of gas are expected to be added to oil and gas fields discovered prior to 1992. More than half of the estimated inferred reserves of oil in the Lower 48 States are in regions 5 (West Texas and Eastern New Mexico) and 2 (Pacific Coast). Almost two-thirds of the estimated inferred reserves of gas are in regions 6 (Gulf Coast) and 7 (Midcontinent).

INTRODUCTION

The purpose of this paper is to describe the data and methods used for to make estimates of inferred reserves for the 1995 U. S. Geological Survey's (USGS) National Assessment of Oil and Gas Resource. The National Assessment publications (USGS, 1995a and 1995b) include estimates of the inferred reserves for Alaska and for the Lower 48 States(Table 1) but excludes Federal offshore. A further purpose of this paper is to present and interpret estimates of inferred reserves at a regional-level. Growth of reserves in continuous-type deposits, such as gas in tight reservoirs, coalbed gas, gas in fractured shales and oil in some shales and the Austin Chalk (USGS, 1995a), are not included in these inferred reserve estimates.

Proved (or measured) reserves of oil or gas are the quantities estimated to be recoverable in future years from known fields under existing economic and operating conditions. The difference between proved reserves in known fields and the actual remaining recoverable resource is inferred reserves. Although reserve growth can be negative, the annual sum of additions to proved reserves (excluding new discoveries) in a large number of fields in the United States is practically always positive (Energy Information Administration, 1990). Estimates of inferred reserves therefore include anticipated additions to proved reserves resulting from applications of improved recovery techniques,reservoir extensions, infill drilling, revisions of proved reserve, and discovery of new pools within existing fields. In this paper the term, "known recovery", represents cumulative production plus proved reserves at a given point in time. Estimates of future (post 1991) additions to proved reserves from those fields discovered before 1992 are inferred reserves.

Temporal changes in United States reserves can be illustrated by a time series of discoveries using the same set of oil or gas fields. Figure 1 shows two versions of the known recovery of crude oil plus condensate discovered onshore and in State waters of the Lower 48 States from 1900 through 1977. The upper curve is based upon 1991 estimates of known recovery and the lower curve is based upon 1977 estimates of known recovery. Note that even fields more than 50 years old have shown growth between 1977 and 1991. Figure 2 shows two versions of known recovery from 1900 through 1977 of wet gas. As with oil, the lower curve is based upon 1977 estimates of known recovery and the upper curve is based upon 1991 estimates of known recovery.



Analysis of historical changes in known recovery provides a basis for extrapolation into the future. Extrapolation can be made by means of a growth function derived from past changes in known recovery.

GROWTH FUNCTION DEFINED

The estimates of future growth are based upon the pattern of growth in the past. A growth function, $G(n)$, where n is the age of the field in years since the year of discovery, gives the size of the field as a multiple of its estimated known recovery in its year of discovery. The year of discovery corresponds to $n = 0$ and hence $G(0)=1$. The ratio $G(n+1)/G(n)$ is the factor by which a field increases as it ages from year n to year $n+1$. The problem of estimating inferred reserves is then equivalent to finding the growth function that best describes how fields have grown in the past, and then applying that function to existing fields to estimate future reserve growth.

The Energy Information Adminstration (EIA) has created the Oil and Gas Integrated Field File (OGIFF) which lists the estimated size for each oil and gas field in the United States. Fifteen estimates of size, as estimated in each of the 15 years 1977 through 1991, are given for each field. An earlier version of the unpublished OGIFF data is described in EIA (1990, p. 2). These are the basic data from which the pattern of field growth is calculated.

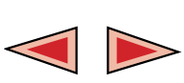
For ease of reference let $c(d,e)$ be the quantity of oil or gas discovered in year d and estimated in year e. From the OGIFF data one can make a discovery table having 92 rows and 15 columns of all $c(d,e)$ where $d = 1900,...1991$ and $e = 1977,...,1991$. Given a growth function $G(n)$, $n = 0,...,91$ it is theoretically possible to estimate most entries in a column in such a table from any earlier column to its left from the relation

$$\hat{c}(d,e+k) = c(d,e) * \frac{g(e+k-d)}{g(e-d)} + \varepsilon(d,e,k) \qquad (1)$$

where k denotes the time elapsed between an early estimate year, e, and the later estimate year, $e+k$. The hat above the variable on the left hand side distinguishes the variable from the data, $c(d,e+k)$. The sum of squares of error, SSE, is given by

$$SSE = \sum_{d,e,k} (\varepsilon(d,e,k))^2 \qquad (2)$$

The sum includes all combinations of d,e, and k for which neither $c(d,e)$ nor $c(d,e+k)$ is 0. The best growth function, $G(n)$, is that which has the smallest SSE among all the allowable growth functions. The allowable growth functions are those which satisfy the two following inequalities



$$1 \le \frac{g(n+1)}{g(n)} \le \frac{g(n)}{g(n-1)}, \qquad n \ge 1 \qquad (3)$$

The left inequality means that fields cannot shrink as they age. The right inequality means that an older field cannot grow by a larger factor in one year than a younger field. Procedures for estimating the final form of *G(n)* are described in Attanasi and Root(1994).

ESTIMATING FIELD GROWTH IN THE LOWER 48 STATES

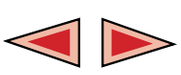
For the purpose of estimating growth functions, the oil and gas provinces of the Lower 48 States are grouped in 7 regions (regions 2 through 8 in fig. 3) and the individual fields in these regions are divided into oil fields and gas fields. A gas field was defined as having a wet gas -to-liquids ratio of 20,000 or more cubic feet of gas per barrel of recoverable associated oil plus condensate. Growth functions were calculated for each region 2 through 8, individually, and for the Lower 48 States as a whole. Growth functions were calculated for primary commodities, that is, for oil plus condensate in oil fields and for wet gas in gas fields. The secondary commodities, associated-dissolved gas in oil fields and oil plus condensate in gas fields, were assumed to grow proportionally to the primary commodities. For example, oil in gas fields was assumed to grow proportionately to the gas. It was also assumed that fields would not grow after age 90 years.

The growth functions (one for oil and one for wet gas for regions 2 through 8 plus one for oil and one for wet gas in the Lower 48 States as a whole) were applied to the EIA known recovery as of yearend 1991. Each of the figures 4 - 17 show regional projected known recovery estimates resulting from application of the growth functions to the EIA data for the primary commodities for regions 2 through 8. One curve for each region was calculated using growth functions based upon the data for that region. The other curve was calculated using a growth function based upon aggregate Lower 48 States data. Also shown on these figures are curves for the sum of the primary and secondary commodities in the regions grown by both the regional and Lower 48 functions. Growth estimates for Alaska (Region 1) and the Lower 48 regions are discussed separately later in this paper.

Figures 18 and 19 show the results for the primary and secondary commodities (oil and wet gas) for the Lower 48 States calculated in two different ways; first, using the growth functions calculated for the Lower 48 States. Second, growth was calculated for the Lower 48 States as the sum of the growth estimated for Regions 2 through 8 using regional growth functions. An unfortunate characteristic of all known methods of estimating growth is that the sum of the estimated regional growths is not exactly the same as the growth of the Lower 48 States estimated as a whole.

ESTIMATING GROWTH IN ALASKA

Graphs showing the time sequence of future additions to known recovery for Alaska are not presented because we do not think the situation in Alaska is predictable at that level. Alaska, Region 1, contains large oil and gas reserves that are concentrated in a relatively small number of fields when compared to the Lower 48 regions. In addition, special operating conditions influence the development of Alaskan oil and gas fields. Because of these factors, and in particular, because of the limited number of fields in Alaska, it was decided that the statistics



of growth for Alaskan fields would not yield reliable growth functions for that area. We elected to estimate potential growth of Alaskan fields through application of Lower 48 national growth functions. This was done because, given the age of the Alaskan fields, national growth functions seemed to yield the most reasonable results. The national functions were then used to calculate the primary commodities from the EIA data for Alaska. The secondary commodities were assumed to grow proportionately to the primary commodities except for associated gas in Prudhoe Bay.

The gas resources of Prudhoe Bay of 24.6 TCF which were considered to be reserves by EIA up until 1988 were added to the Alaskan inferred reserves estimate of associated-dissolved gas because of the high probability that these resources would become reserves sometime in the next 80 years and would not otherwise be accounted for. We did not add any additional inferred oil reserves to the North Slope to account for the growth in the large discovered heavy oil resources at West Sak and Ugnu because we believe these are covered by the large estimated growth of inferred oil reserves at Prudhoe Bay Field. These heavy oil reserves in northern Alaska could become economic in the next 80 years and might account for the large, and perhaps overly optimistic, estimates of growth in Prudhoe Bay Field. We believe the growth estimates for Prudhoe are overly optimistic because of the sophisticated, modern technology that has been applied at the Prudhoe Bay Field since its discovery.

NATIONAL RESULTS

Table 1 shows the growth of oil, dry gas, and natural gas liquids for Alaska and for the Lower 48 States. In table 2, the growth of the three commodities is allocated to regions 2 through 8. Table 2 also shows the actual growth of reserves in fields discovered prior the 1978 from their size as estimated in 1977 to their size as estimated in 1991.

We estimate the inferred reserves of oil onshore and in State waters of the United States are about 60 billion barrels of oil (BBO). Of these 60 BBO, approximately 13 BBO are estimated to be in Alaska, and the remaining 47 BBO in the onshore and State waters areas of the Lower 48 States (table 1).

We estimate the inferred reserves of dry gas onshore and in State waters of the United States are about 322 trillion cubic feet (TCF). Of these 322 TCF, approximately 32 TCF are estimated to be in Alaska, and the remaining 290 TCF in the onshore and State waters areas of the Lower 48 States (table 1).

Lower 48 Oil Growth

Figure 18 shows the estimated future growth of oil from 1991 through 2071 for the Lower 48 States calculated in two different ways. Figure 18 includes both primary and secondary commodities. In the upper curve the Lower 48 States were treated as a unit. The growth curve for the Lower 48 was calculated and then the 1991 estimate of known recovery of past discoveries was projected ahead to 2071. The upper curve shows that fields totaling 158 BBO in known recovery in 1991 are projected to increase to 205 BBO in 2071 for a growth of 47 BBO. In the lower curve, the growth was estimated for each of the seven regions separately and the results were summed. It is apparent that the results of the two procedures are close but not identical. The sum of the regional growth

estimates leads to a growth from 158 BBO in known recovery to 200 BBO for a growth of 42.7 BBO.

The two curves are so close even 20 years into the future, that the difference is not of practical significance. The growth of the oil fields in the Lower 48 States discovered before 1992 is taken to be 47 BBO and this growth is allocated to the regions proportionally to their individual contributions to the 42.7 BBO (Table 2). While a total of 47 BBO might be added to reserves during the 80 year period following 1991, we estimate that roughly 20 BBO will be added to reserves over the next 20 years from fields discovered before 1992.

Lower 48 Gas Growth

With respect to growth of reserves of wet natural gas in the Lower 48 States, figure 19 shows the results of two projections known recovery for 80 years after the end of 1991. In the upper curve the Lower 48 States are treated as a unit. In the lower curve the growth is calculated separately for the individual regions and then summed. As with oil, the curves are close, but are not identical. When the Lower 48 States are treated as a unit, the growth is from 782 TCF in known recovery to 1086 TCF for total growth of 304 TCF. When the individual regions are treated separately and their growth summed, the result is growth from 782 TCF in known recovery to 1044 TCF for a total growth of 262 TCF. The difference between the curves is small enough and far enough into the future that it is not of practical significance. Whether the national curve or the sum of the regional curves is used, it is projected that about 100 TCF will be added to reserves in conventional gas fields during the 20 years after.

The conversion from wet natural gas of figure 19 to dry natural gas, as in tables 1 and 2 is based on national averages (EIA, 1994): 170 TCF wet gas = 162 TCF dry gas + 7.222 BBO natural gas liquids (NGL). Using this relation the growth of 304 TCF wet gas converts to 290 TCF dry gas and 12.9 BBO of NGL. The growth of dry gas in the Lower 48 States discovered before 1992 is calculated to be 290 TCF and this growth is allocated to the regions proportionally to their individual contributions to the 262 TCF (Table 2).

LOWER 48 REGIONAL GROWTH ESTIMATES

Figures 4 through 17 are regional growth curves for regions 2 through 8, calculated using only data from within each region, and growth curves for the same region calculated using the Lower 48 growth functions. Each figure shows two curves for primary commodities and two curves for the sum of primary and secondary commodities. The primary commodities are oil in oil fields and wet gas in gas fields. The curves calculated from regional data will be called regional growth. The curves calculated from Lower 48 data will be called Lower 48 average growth.

Region 2 - Pacific Coast

In figure 4, Oil regional growth is much higher than the Lower 48 average growth. This is due to the relatively late development of many large, heavy oil fields in California using steam flood recovery technology. In addition the full development of the giant Elk Hills field was delayed until after the 1973 oil embargo because it was a Naval Petroleum reserve. The curves with and without oil as a secondary commodity coincide because there is virtually no oil in gas fields in region 2.

Gas in the Pacific Coast region occurs mainly in the Sacramento basin, where low regional growth is displayed relative to the Lower 48 growth

(Fig. 5). This probably reflects the fact that there are a limited number of reservoirs in the basin and so there are few additions to reserves as a consequence of the discovery of new reservoirs in existing fields. In contrast to the oil curves the gas curves with and without associated-dissolved gas are widely separated because of the large amount of gas associated with region 2 oil fields.

Region 3 - Colorado Plateau and Basin and Range

Oil inferred reserves (Fig. 6) show a much larger growth when based on the Region 3 growth function than when based on the Lower 48 growth function. The principal reasons for this difference are extensive infill drilling and the application of improved oil recovery methods. A review of the past growth of oil reserves in Region 3 shows that large growth is present in most of the fields. This result is somewhat surprising and it should be noted that the Region 3 oil field data set which included only 241 oil fields is small in comparison to most of the other regions. It may be that our estimate of the future growth in this region is too large because of the small data set. There is virtually no oil in gas fields in Region 3.

Gas inferred reserves in Region 3 when based on the regional growth function are smaller than when based on the Lower 48 growth function (Fig. 7). This result is also surprising because of the large past additions to gas reserves in the region. We believe that this results since 33 fields were removed from the data set because they contained unconventional gas accumulations. It is likely that a large part of the gas reserve growth in the region has come from unconventional accumulations, but it is also likely that some important growth in conventional gas reserves was removed from the data set because it was in fields that also had unconventional gas. The size of the gas reserve data set is also small, 203 gas fields, than the data sets in most other regions. We believe that future gas growth in region 3 will probably be higher than our estimate and could account for some of the difference between the Lower 48 growth estimate and the sum of the regional growth estimates shown in (Fig. 19)

Region 4 - Rocky Mountains and Northern Great Plains

Regionally based growth of oil reserves is somewhat larger than results obtained using Lower 48 growth functions (Fig. 8). We attribute this to extensive infill drilling and application of advanced recovery technologies such as CO2 floods and waterfloods in this region during much of the period over which the data were collected (1977-1991).

In Figure 9, Region 4 also shows short lived regional gas growth compared to lower 48 average growth. This mostly reflects the removal of many fields containing continuous-type accumulations from the Region 4 data set. Most growth has been occurring in fields containing at least some continuous-type gas accumulations. The few fields before 1930 showed little growth. Also, gas transportation from the Rockies has been, until very recently, somewhat restricted due to the limited availability of gas transmission systems in the region. Thus, the development of gas resources may have been curtailed during much of the period covered by the data. Greater rates of growth in the future might be anticipated in spite of the very low estimates contained herein.

Region 5 - West Texas and Eastern New Mexico

Figure 10 displays very large absolute growth resulting from geologically directed infill drilling and application of advanced recovery technologies in the Permian Basin. Regional and Lower 48 average growth are similar because oil in this region accounts for a large part of Lower 48 reserves.

Gas in Region 5 (Fig. 11) displays lower regional growth rates than the Lower 48 average. However, inferred reserves in this region are large overall, probably representing 20 TCF or more. Much Permian Basin gas was developed relatively recently so that large amounts of gas occur in comparatively young (in terms of discovery) fields. As a consequence, larger future growth is anticipated than the regional curve shows because the regional growth function effectively terminates growth at 60 years after discovery.

Region 6 - Gulf Coast

Oil reserves display the lowest regional growth rates (Fig. 12) compared to the Lower 48 averages of any region in the Lower 48 States. This low growth rate probably results from the fact that most Gulf Coast fields are water drive fields and thus past reserve revisions due to application of secondary recovery are much smaller than elsewhere.

Regional growth of gas reserves in Region 6 (Fig. 13) is somewhat lower than the Lower 48 average but is nevertheless an enormous quantity, amounting to nearly 100 TCF of gas to be added to reserves in known fields. Growth in Region 6 reflects continuous extensions, and the discovery and development of new reservoirs. Revisions have been relatively unimportant.

Region 7 - Midcontinent

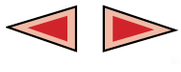
Regional growth in region 7 (Fig. 14) is lower than the Lower 48 average probably because of more intense development in the Midcontinent prior to the years in which the growth data was collected than was the average in the rest of the Lower 48. During the years in which the data were collected the most important source of reserve growth was revisions followed by extensions and the smallest source of growth was new reservoirs.

Regional gas growth (Fig. 15) is higher than the national average reflecting the persistent growth of old fields from extensions and revisions (closer spacing in the giant Hugoton field) and new reservoirs in old fields (deep drilling into the large number of pay zones in the Anadarko basin).

Region 8 - Eastern

The Eastern Region displays relatively low rates of oil reserve growth in comparison to the Lower 48 average (Fig. 16), reflecting the advanced state of development of many of the very old fields in this area. Not only that, but most fields are shallow and developed on very close spacing, i.e. 5-10 acres. Consequently few additions result from infill drilling. Also, this is an area where water flooding was first applied, so reserve additions resulting from water flooding occurred long ago and are not reflected in the 1977-1991 growth data.

Gas in Region 8 displays growth that is significantly lower than the national average. An important reason for the apparent low growth is that all those fields containing significant continuous-type deposits were deleted from the data base. Much of the growth of reserves in this region over the period covered by the data has been in continuous-type deposits and many of the gas fields that are present are relatively old, so large revisions are not expected.



SUMMARY AND CONCLUSIONS

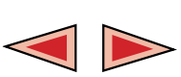
For the first time the inferred reserves from a national assessment of conventional oil and gas resources have been subdivided into regional estimates. This was made possible by the availability of reserve estimates by field from The Energy Information Administration's Oil and Gas Integrated Field File. The sum of the regional estimated inferred reserves are not exactly equal to the estimate for the Lower 48 as a whole, however, we did not find the difference to be of practical significance. As shown in Figs. 18 and 19, projected additions to reserves from the growth of pre-1992 discoveries until 2011 are almost equal whether the estimates are for the Lower 48 grown as a unit or the regions are grown idependently and then summed.

It is estimated that inferred reserves of oil onshore and in State waters of the United States are about 60 BBO. Of these 60 BBO, approximately 13 BBO were estimated to be in Alaska, and the remaining 47 BBO were estimated to be in the onshore and State waters areas of the Lower 48 States (table 1).

It is estimated that inferred reserves of dry gas onshore and in State waters of the United States are about 322 TCF. Of these 322 TCF, approximately 32 TCF were estimated for Alaska, and the remaining 290 TCF were estimated to be in the onshore and State waters areas of the Lower 48 States (table 1).

Compared with the 1989 U. S. Geological Survey's National Oil and Gas Asssessment (Mast and others, 1989) of 21 BBO and 90.2 TCF gas for inferred reserves, the 1995 estimates of future growth represent a significant increase. Limitations of the data used in the earlier assessment restricted field growth to no more than 60 years after discovery. EIA's OGIFF data, however, showed some fields continue to grow 90 years after discovery. Much of the increase in the 1995 estimates is due to the additional 30 years of growth.

More than half of the estimated inferred reserves of oil in the Lower 48 States are in regions 5 (West Texas and Eastern New Mexico) and 2 (Pacific Coast). Almost two-thirds of the estimated inferred reserves of gas are in regions 6 (Gulf Coast) and 7 (Midcontinent).



References

Attanasi, E. D. , and Root, D. H., 1994, The enigma of oil and gas field growth, American Association of Petroleum Geologists Bulletin, v. 78, no. 3, p. 321-332.

Energy Information Administration, 1990, U.S. oil and gas reserves by year of field discovery: DOE/EIA-0534, 137 p.

Energy Information Administration, 1995, U.S. crude oil, natural gas, and natural gas liquids reserves 1994 annual report: DOE/EIA-0216(94), 153 p.

Mast, R.F., Dolton, G.L., Crovelli, R.A., Root, D.H., Attanasi, E.D., Martin, P.E., Cooke, L.W., Carpenter, G.B., Pecora, W.C., and Rose, M.B., 1989, Estimates of undiscovered conventional oil and gas resources in the United States--a summary: USGS/MMS Special Publication, 44 p.

U.S. Geological Survey National Oil and Gas Resource Assessment Team, 1995a, 1995 National Assessment of United States Oil and Gas Resource Assessment: U.S. Geological Survey Circ. 1118, 20 p.

U.S. Geological Survey National Oil and Gas Resource Assessment Team, 1995b, 1995 national assessment of United States oil and gas resources--results, methodology, and supporting data: Gautier, D. L., Dolton, G. L., Takahashi, K. I., and Varnes, K. L., Eds., CD-ROM U.S. Geological Survey Digital Data Series DDS-30.

Table 1. Estimated future growth (inferred reserves) of fields discovered as of December 31, 1991

Area	Crude oil (billion barrels)	Dry Gas (trillion cubic feet)	NGL (billion barrels)
Alaska	13.0	32.0	0.5
Lower 48 States	47.0	290.0	12.9
TOTAL, onshore areas and State waters of the United States	60.0	322.0	13.4

Table 2. Projected and historical growth in known recovery by USGS regions in the Lower 48 States.

	Pre-1992 fields Projected growth 1991-2071			Pre-1978 fields Actual growth 1977-1991		
	Oil	Dry gas	NGL	Oil	Dry gas	NGL
	BBO	TCF	BBO	BBO	TCF	BBO
Region 2	9.6	13.5	0.6	4.8	3.6	0.2
Region 3	4.5	11.8	0.5	0.6	2.3	0.1
Region 4	6.8	19.2	0.9	2.0	7.8	0.3
Region 5	17.6	51.2	2.3	7.3	20.6	0.9
Region 6	2.7	102.4	4.6	2.3	37.3	1.7
Region 7	4.9	88.3	3.9	2.3	37.8	1.7
Region 8	1.0	3.7	0.2	0.7	8.4	0.4
Lower 48	47.0	290.0	12.9	20.0	117.8	5.2

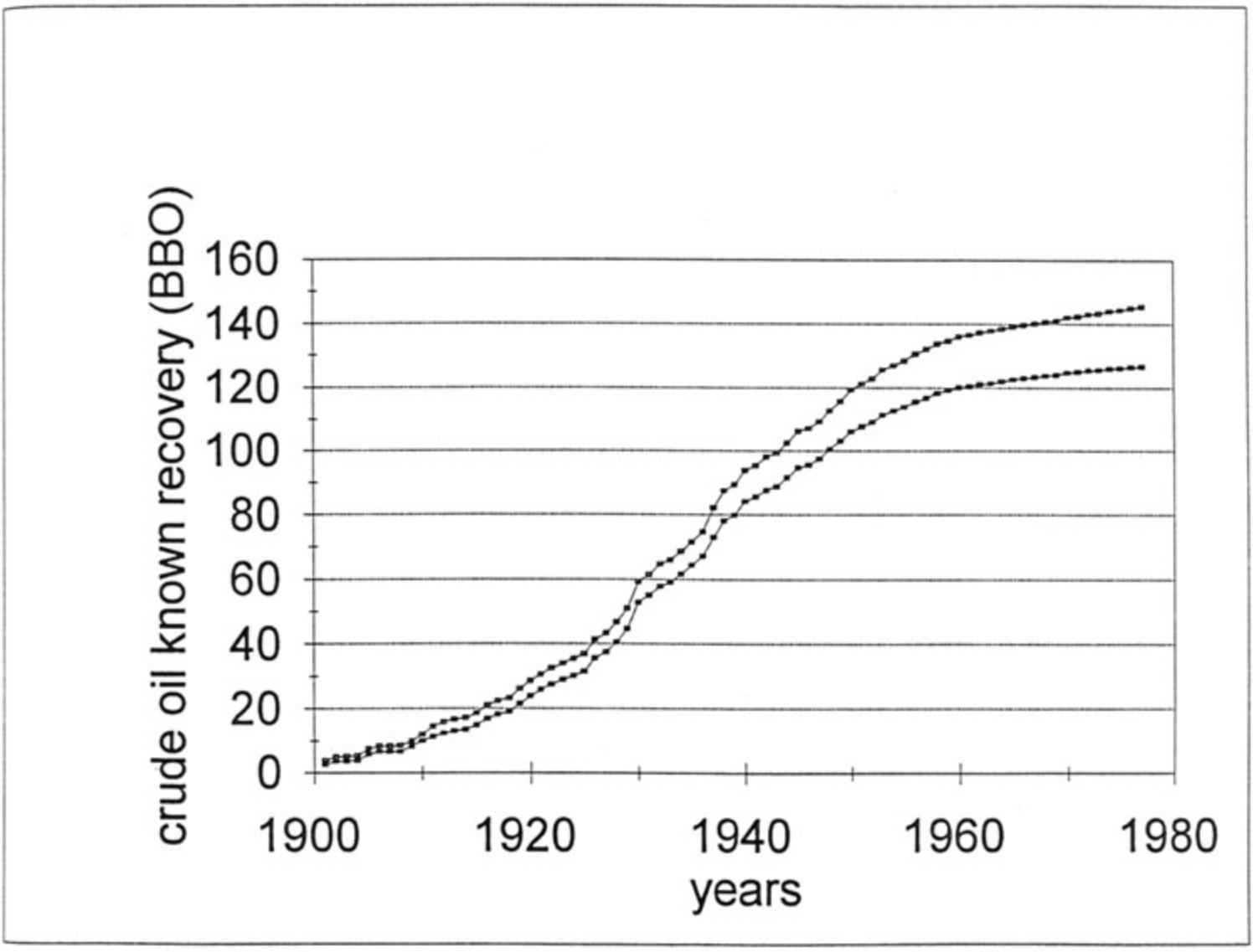


Figure 1. Lower 48 States onshore and state waters. Cumulative known recovery of oil from all oil and gas fields discovered from 1901 through 1977. The upper curve is based on 1991 estimates and the lower curve is based on 1977 estimates. Both curves represent the same fields.

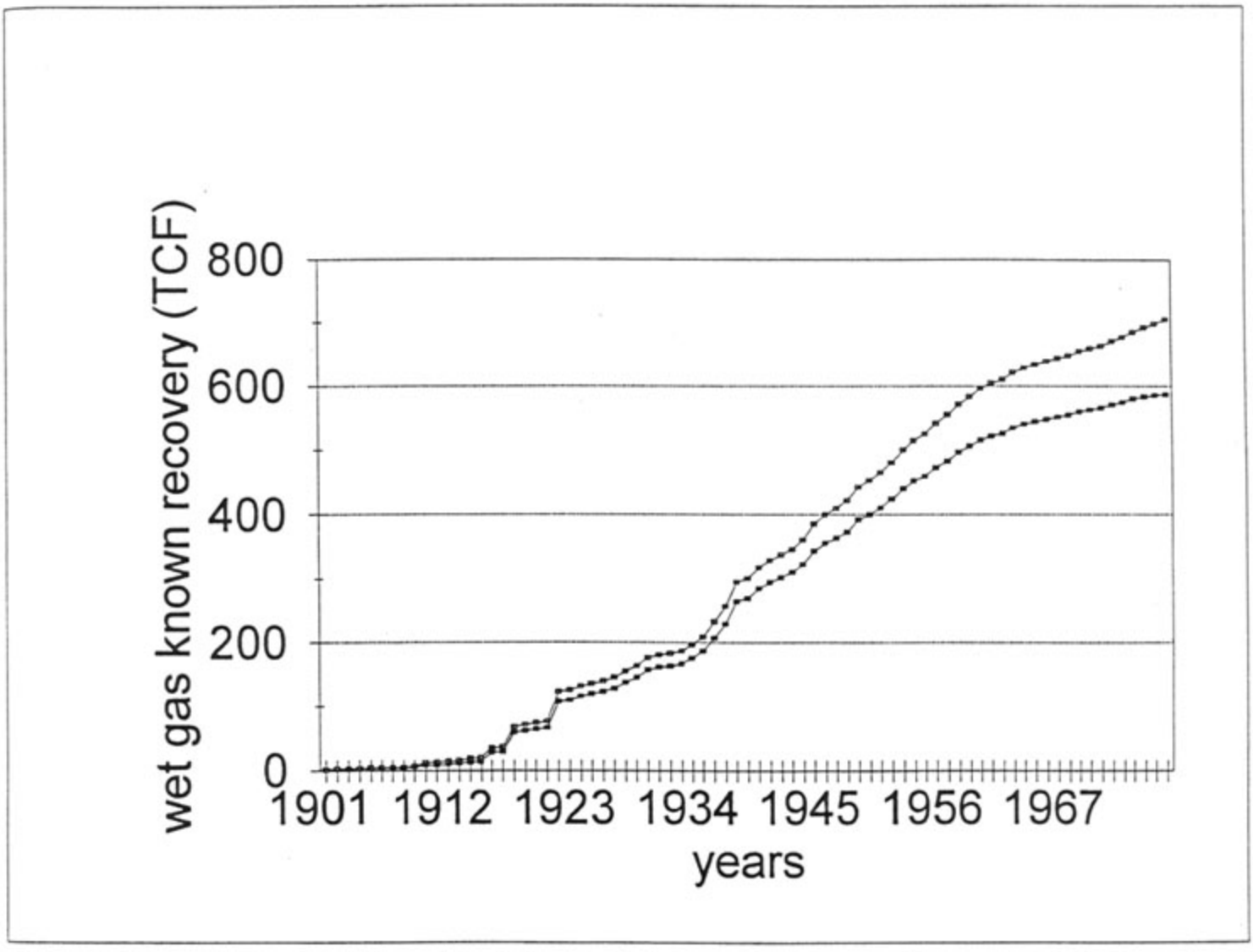


Figure 2. Lower 48 States onshore and state waters. Cumulative known recovery of wet gas from all oil and gas fields discovered from 1901 through 1977. The upper curve is based on 1991 estimates and the lower curve is based on 1977 estimates. Both curves represent the same fields.

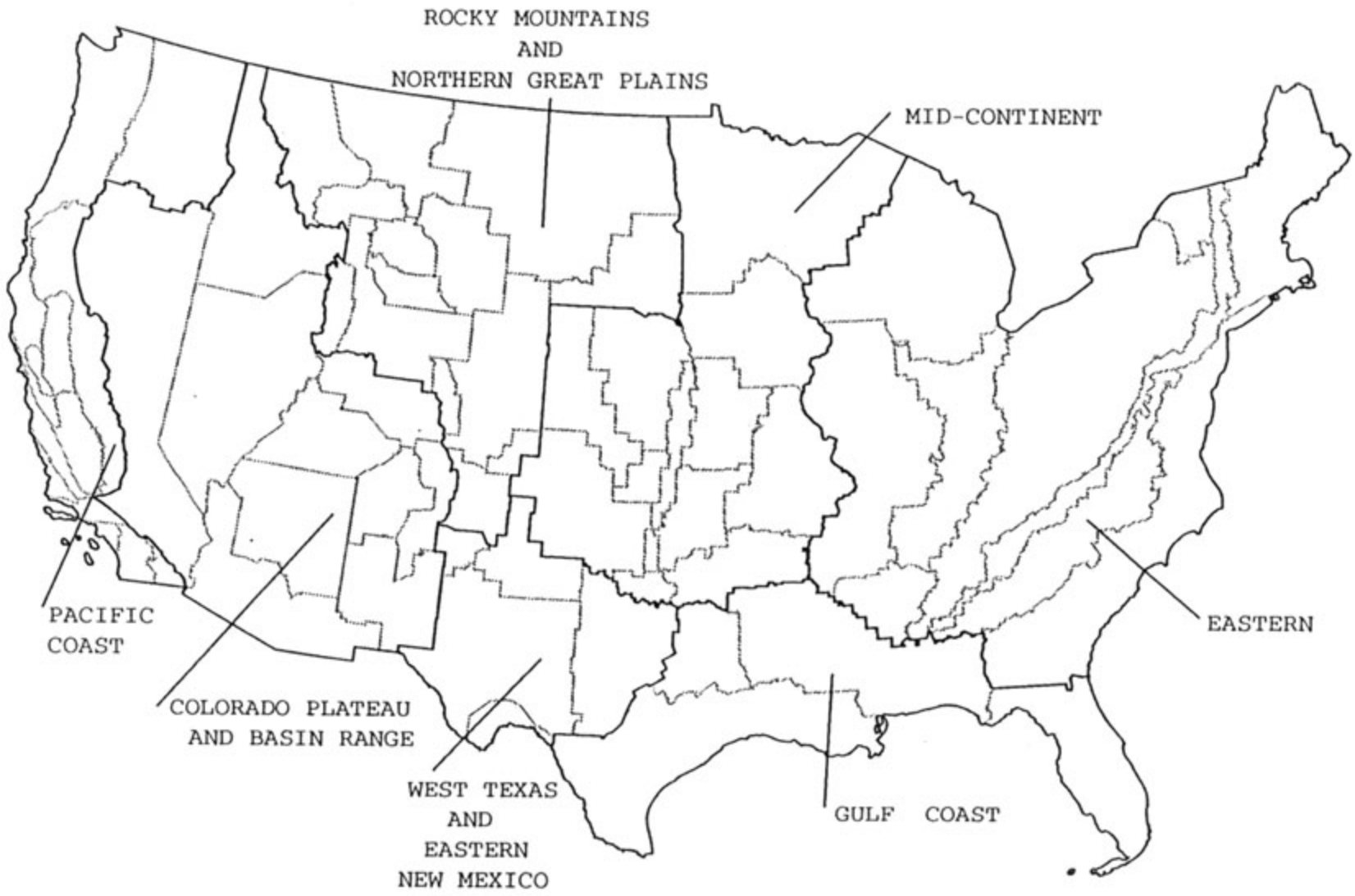


Figure 3. Petroleum regions and provinces. Heavy lines, region boundaries; lighter lines, province boundaries. Maritime boundaries represent the approximate of state offshore boundaries (after USGS 1995a, fig. 3).

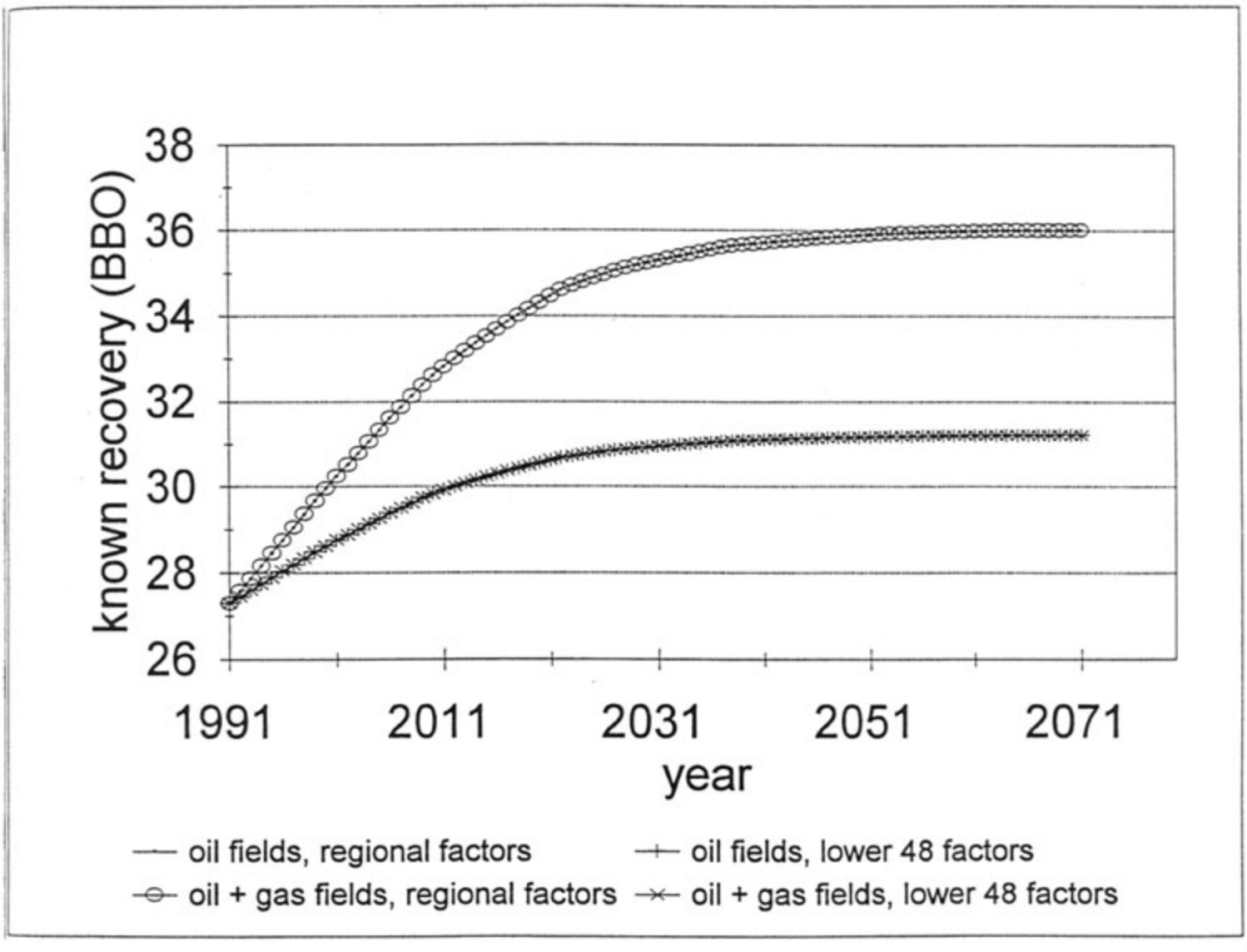


Figure 4. Region 2 Pacific Coast - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

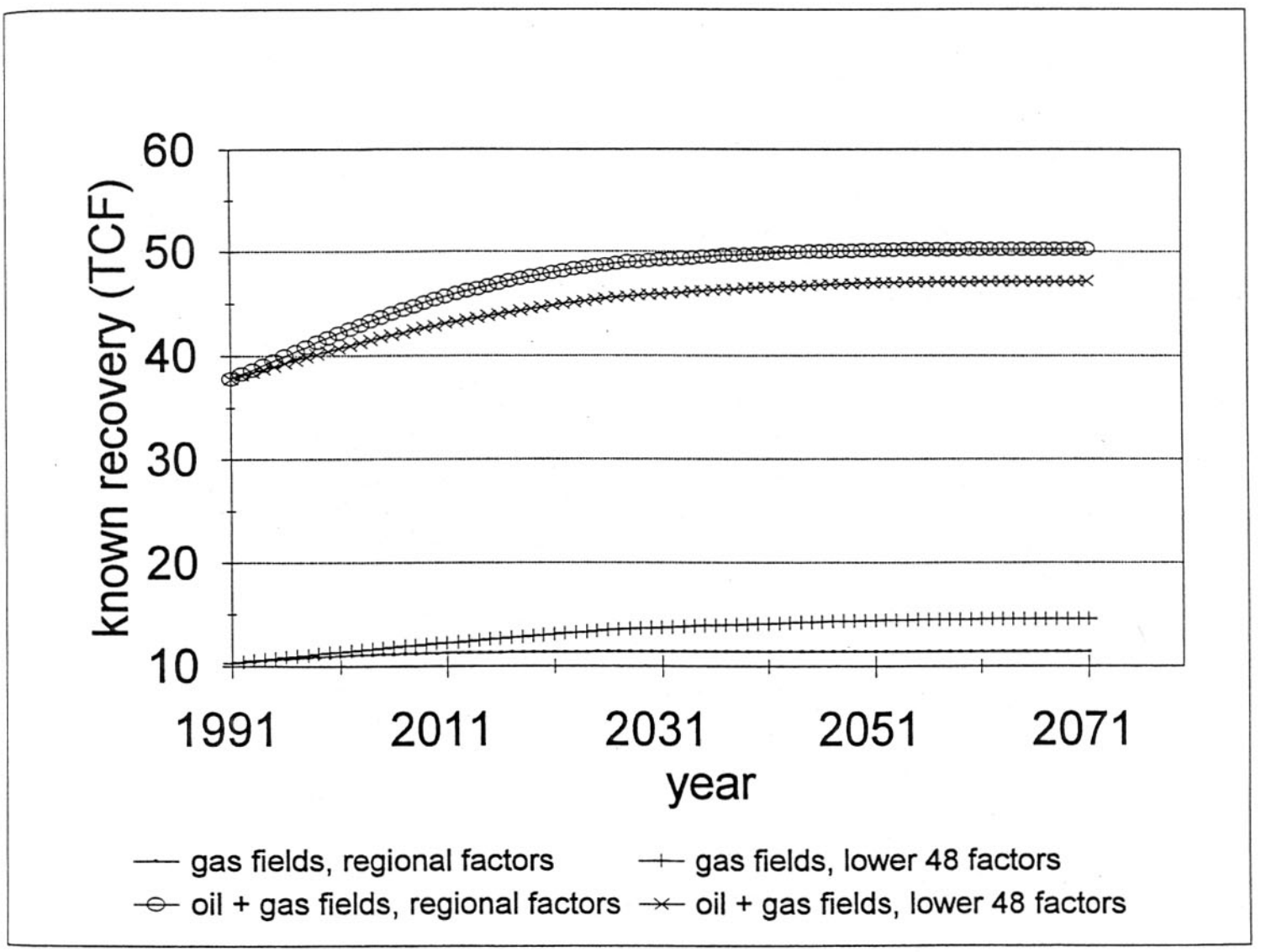


Figure 5. Region 2 Pacific Coast - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

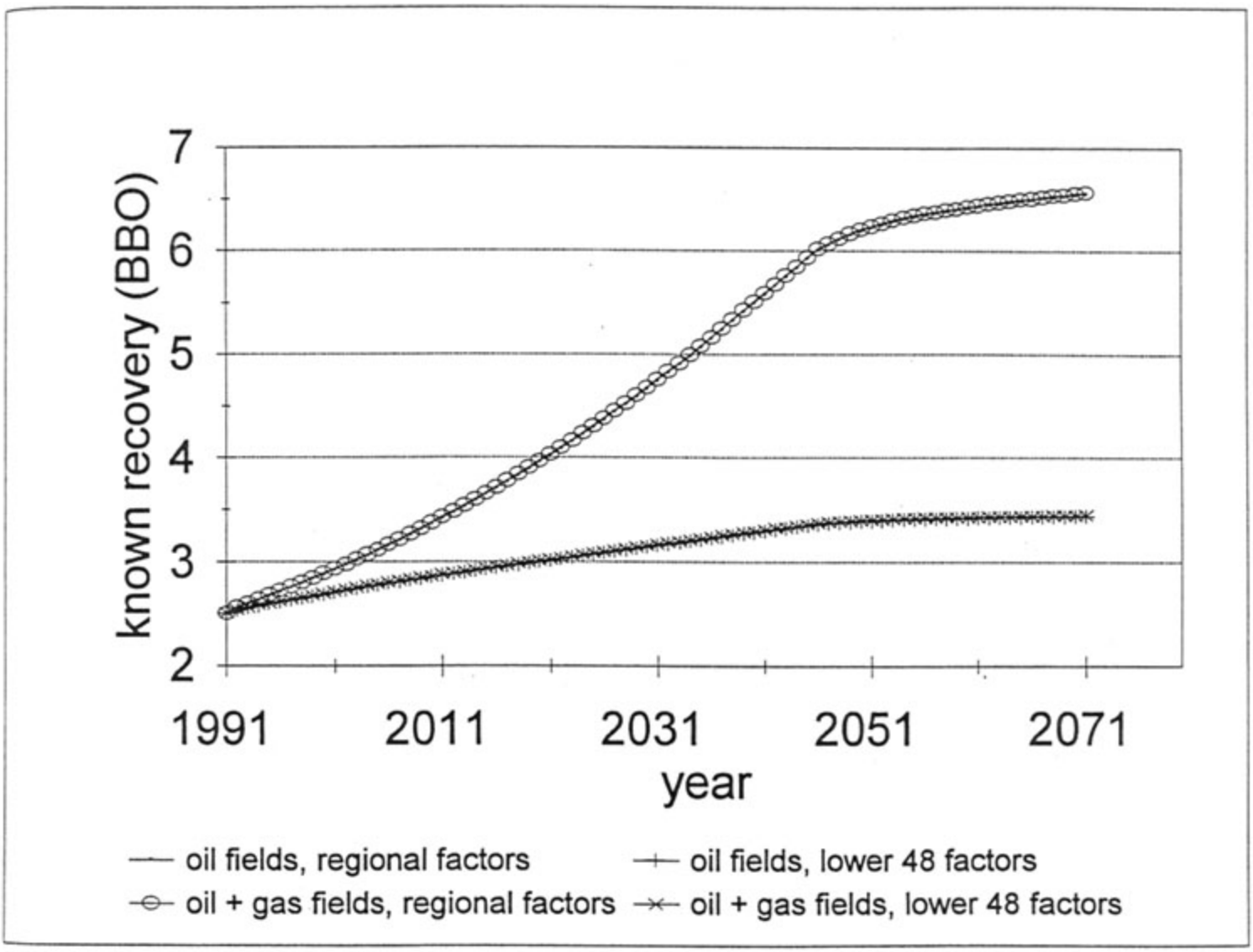


Figure 6. Region 3 Colorado Plateau and Basin and Range - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

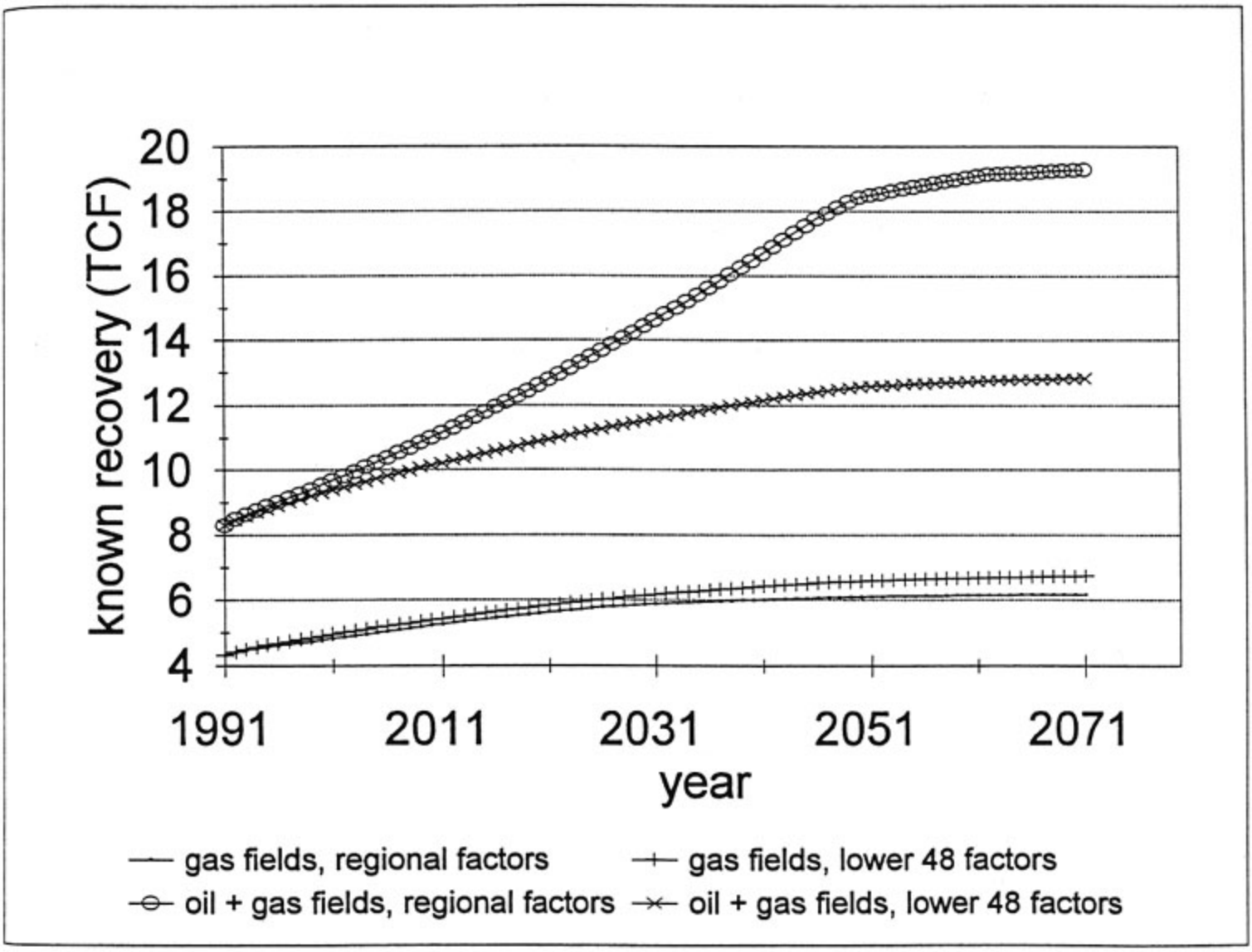


Figure 7. Region 3 Colorado Plateau and Basin and Range - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

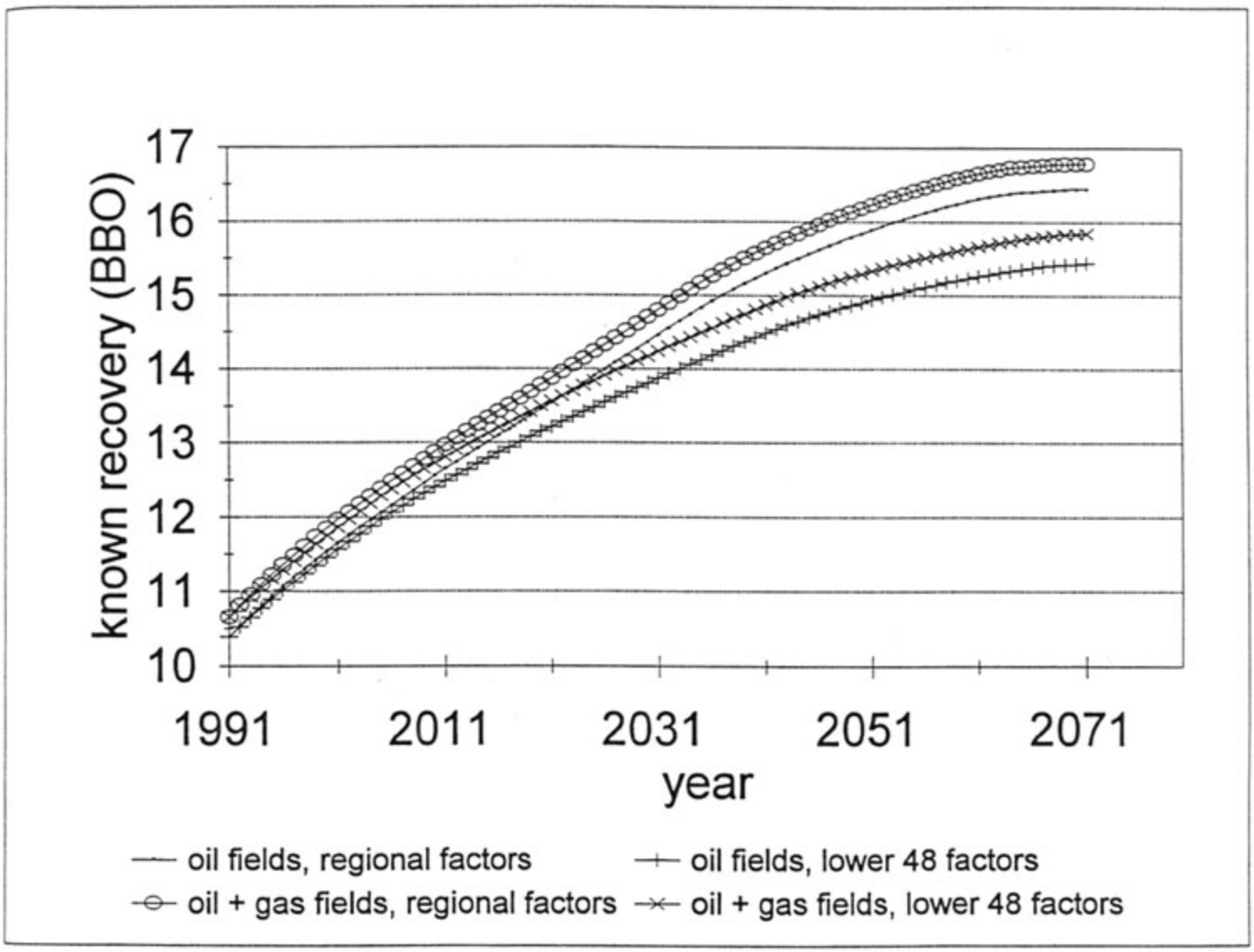


Figure 8. Region 4 Rocky Mountains and Northern Great Plains - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

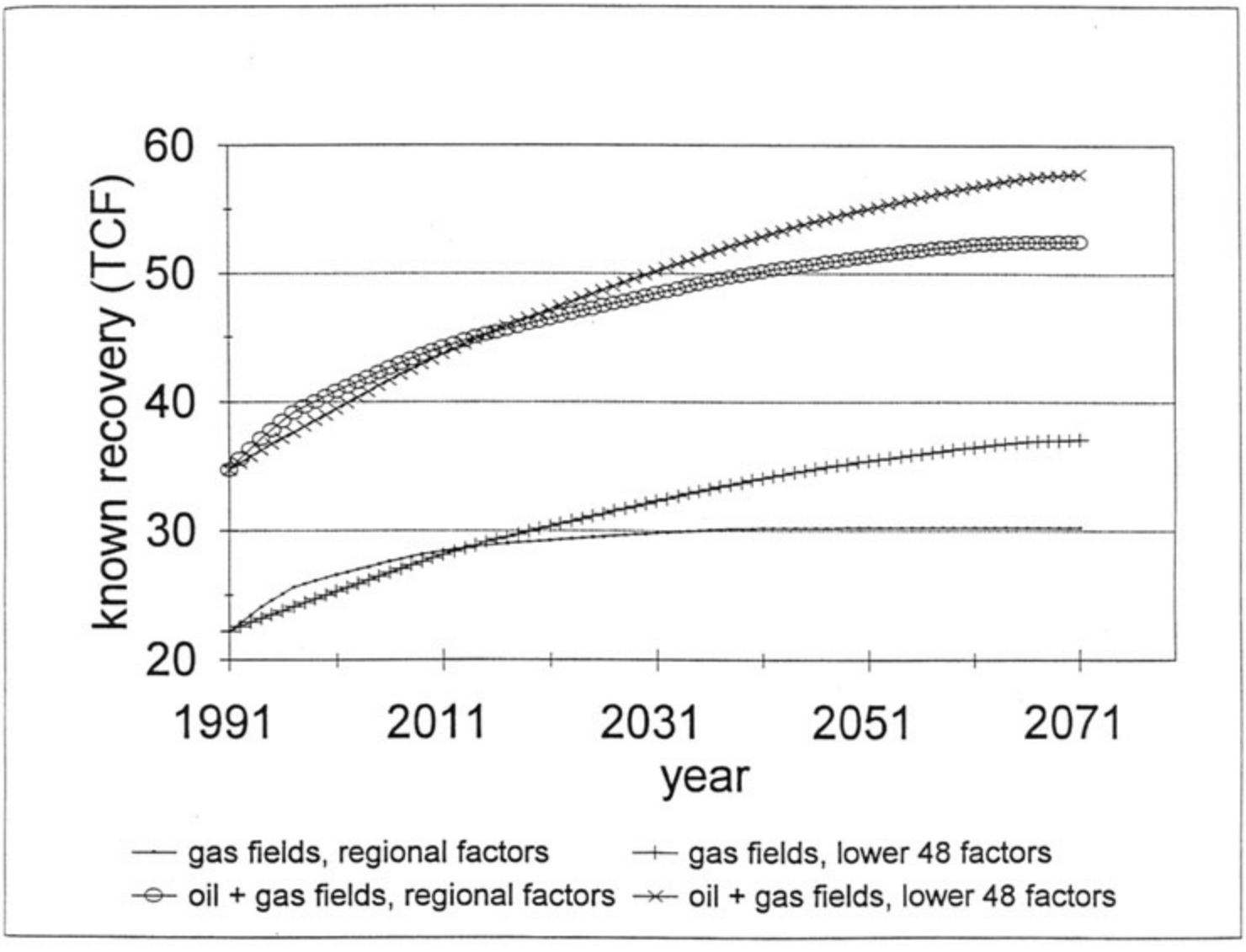


Figure 9. Region 4 Rocky Mountains and Northern Great Plains - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

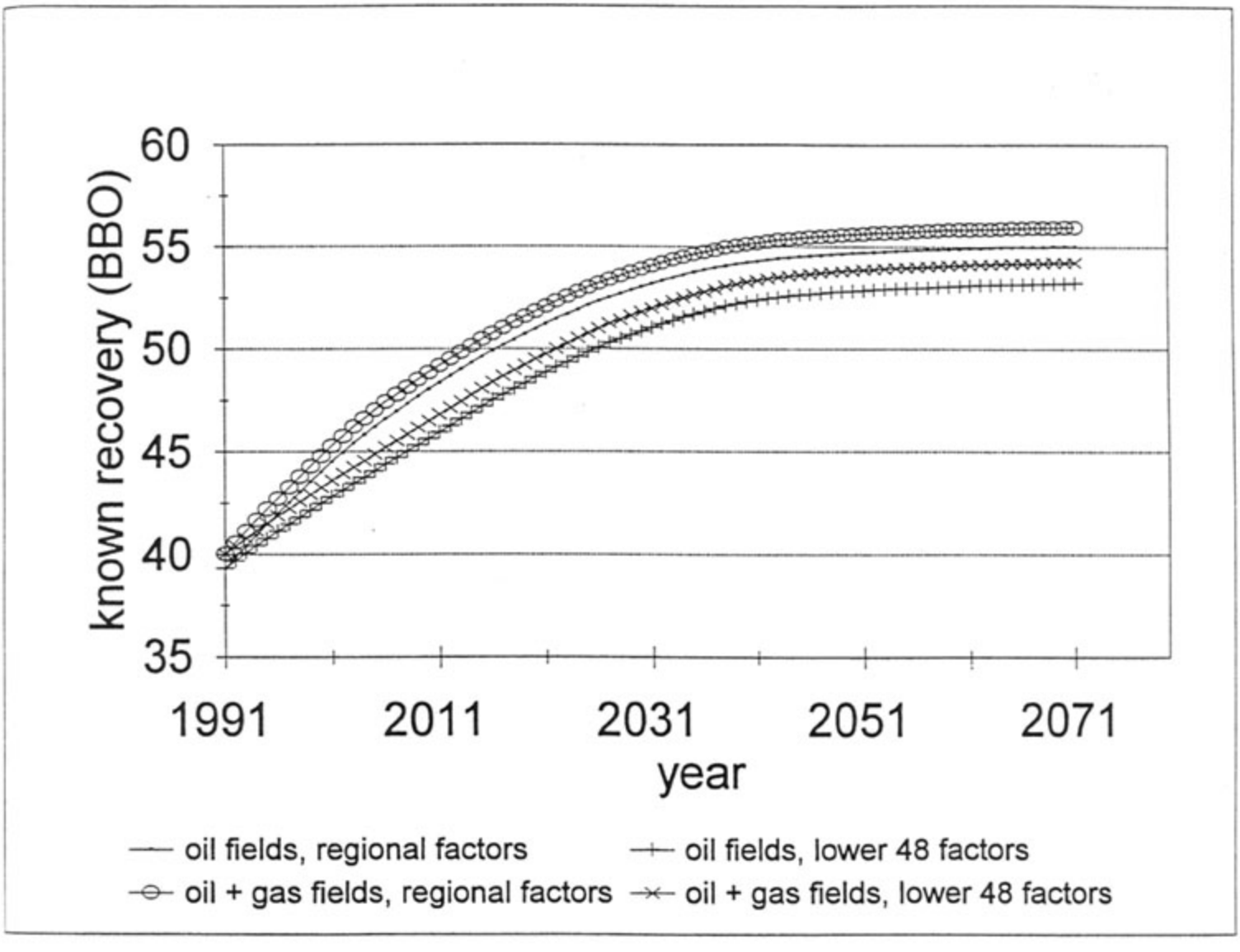


Figure 10. Region 5 West Texas and Eastern New Mexico - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

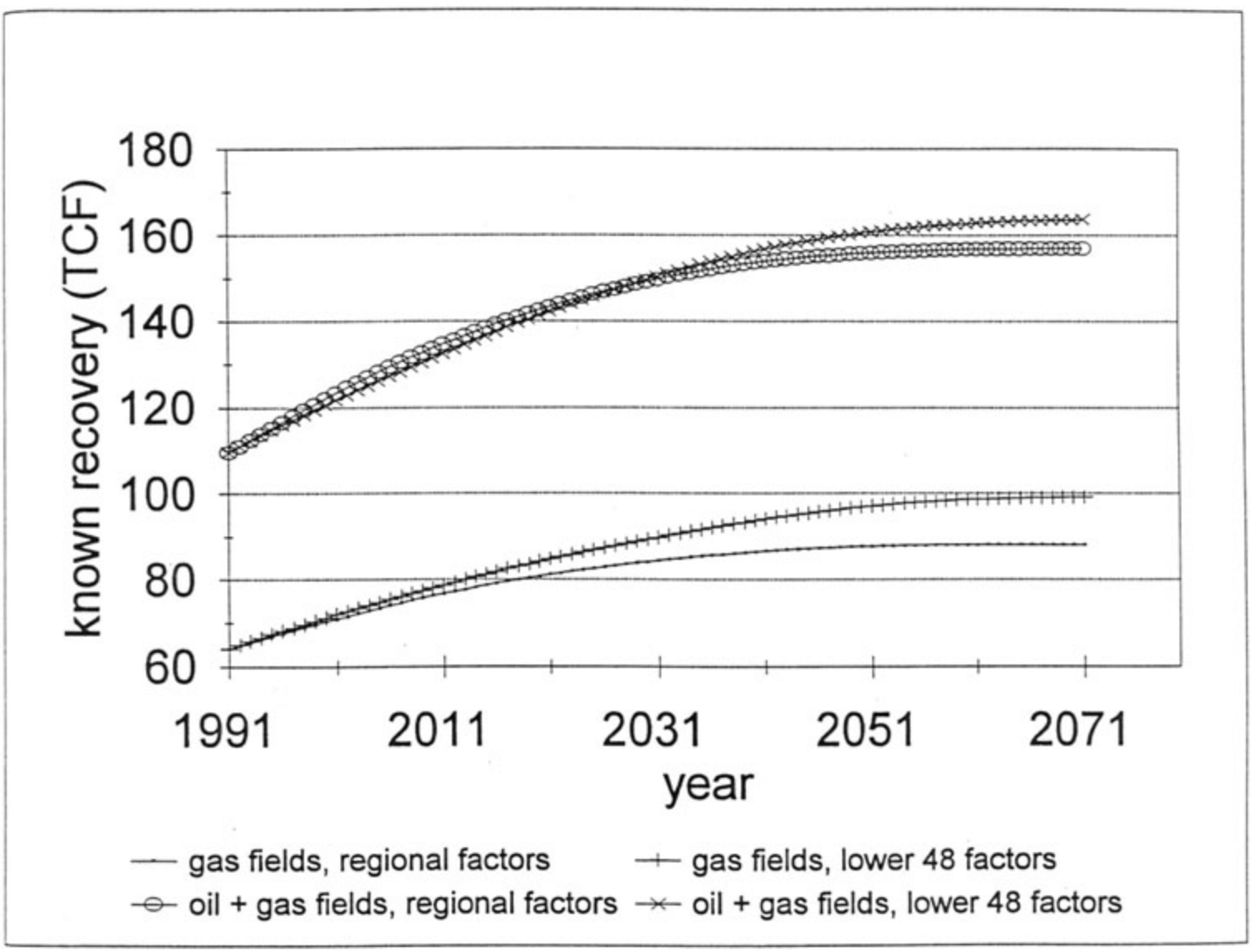


Figure 11. Region 5 West Texas and Eastern New Mexico - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

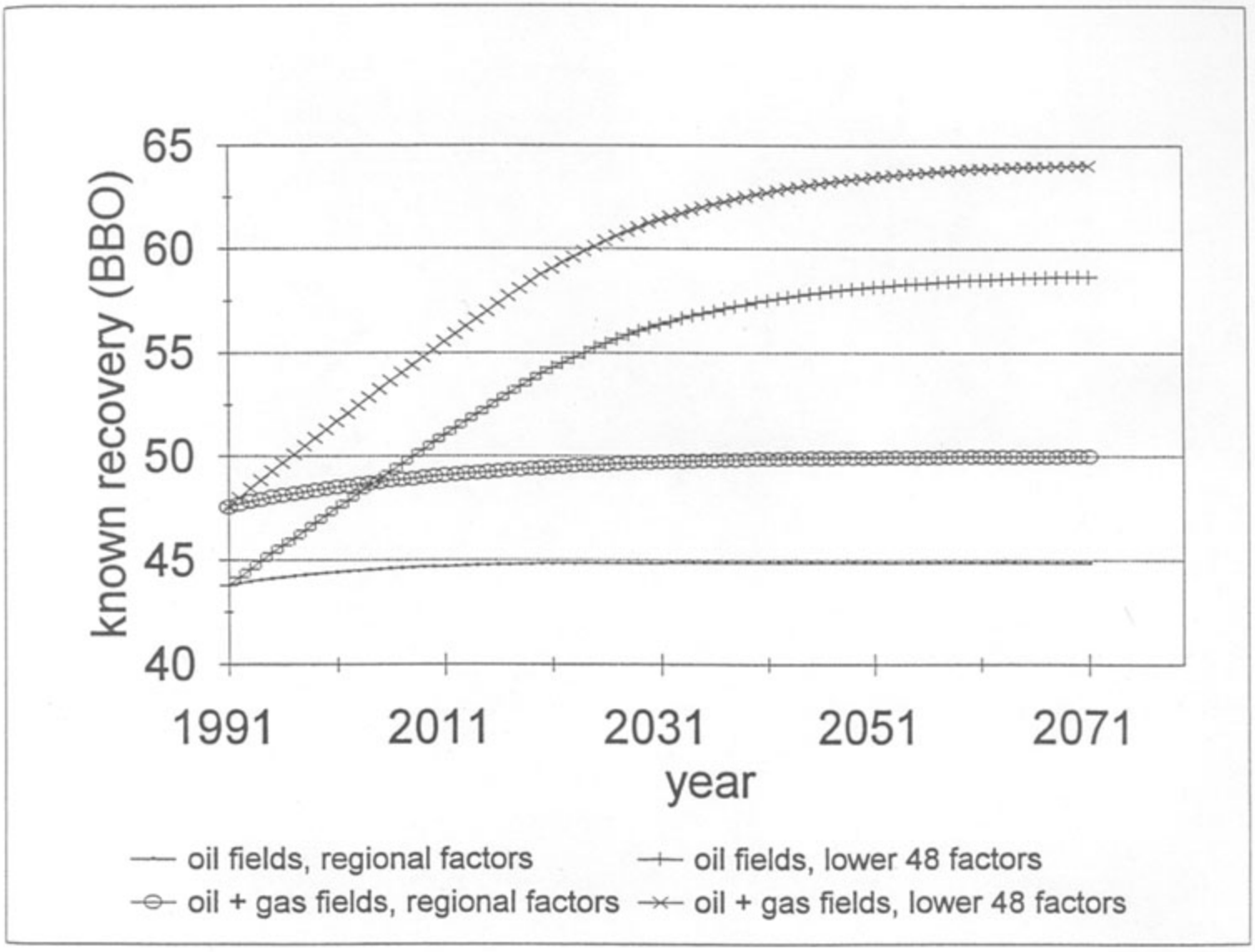


Figure 12. Region 6 Gulf Coast - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

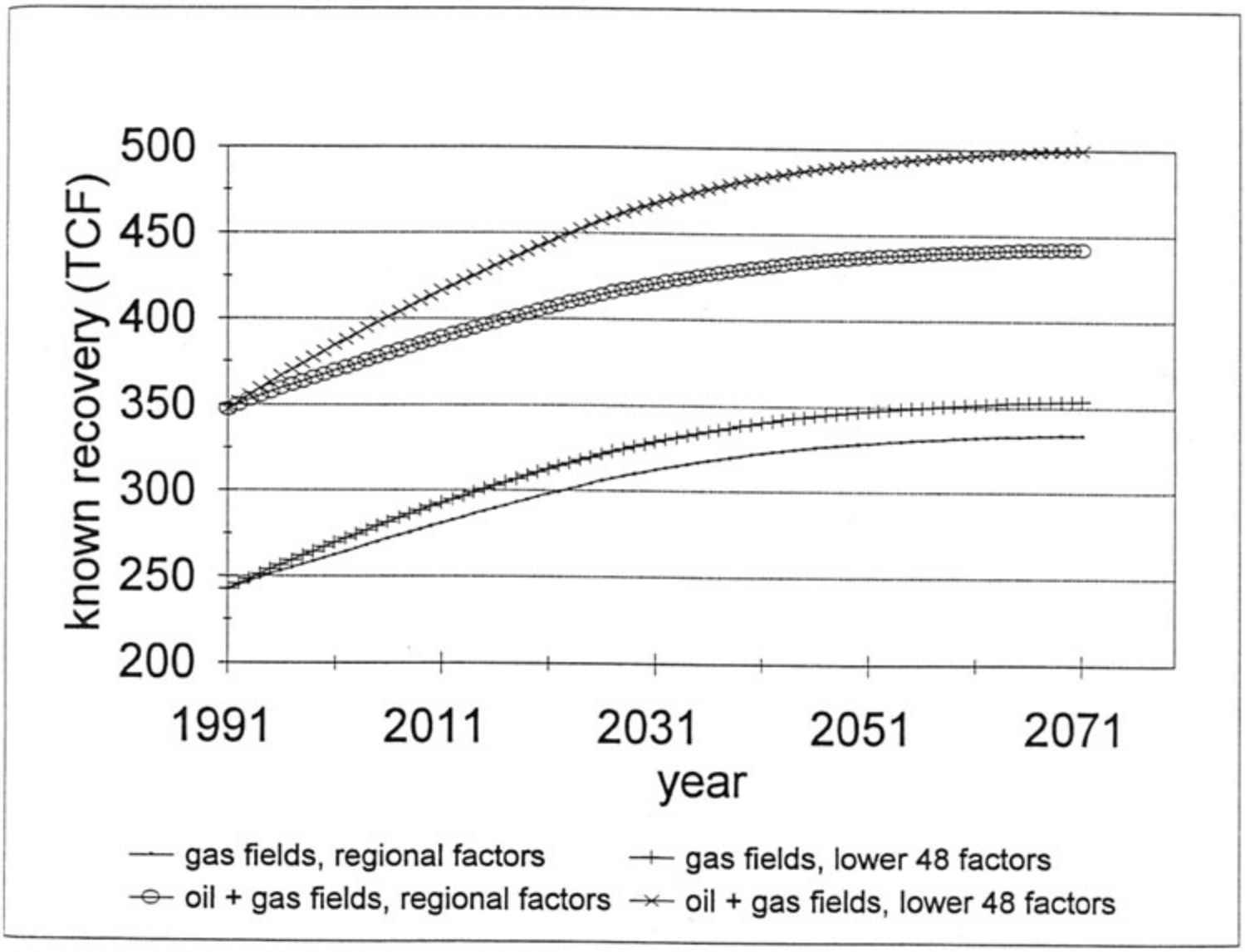


Figure 13. Region 6 Gulf Coast - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

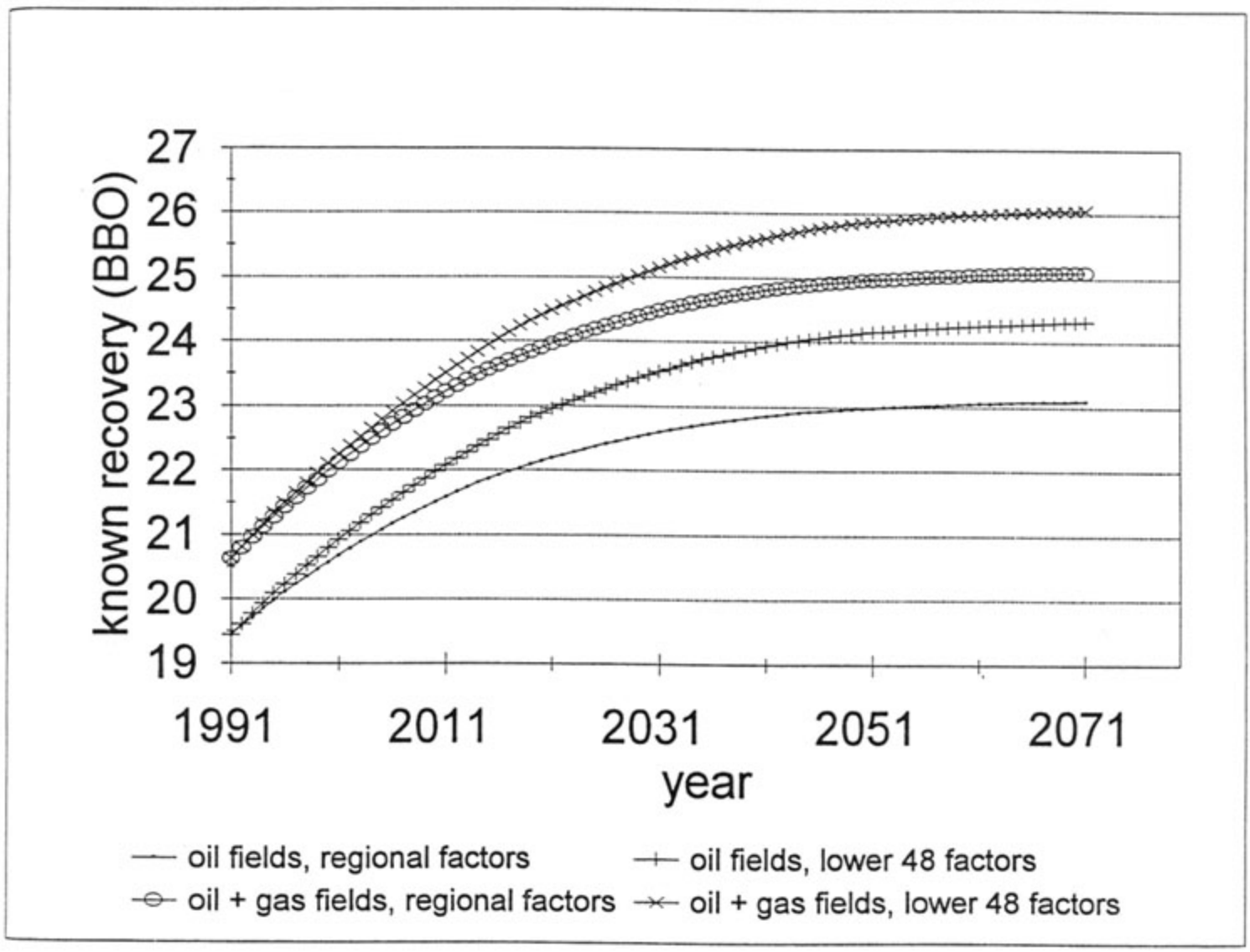


Figure 14. Region 7 Midcontinent - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

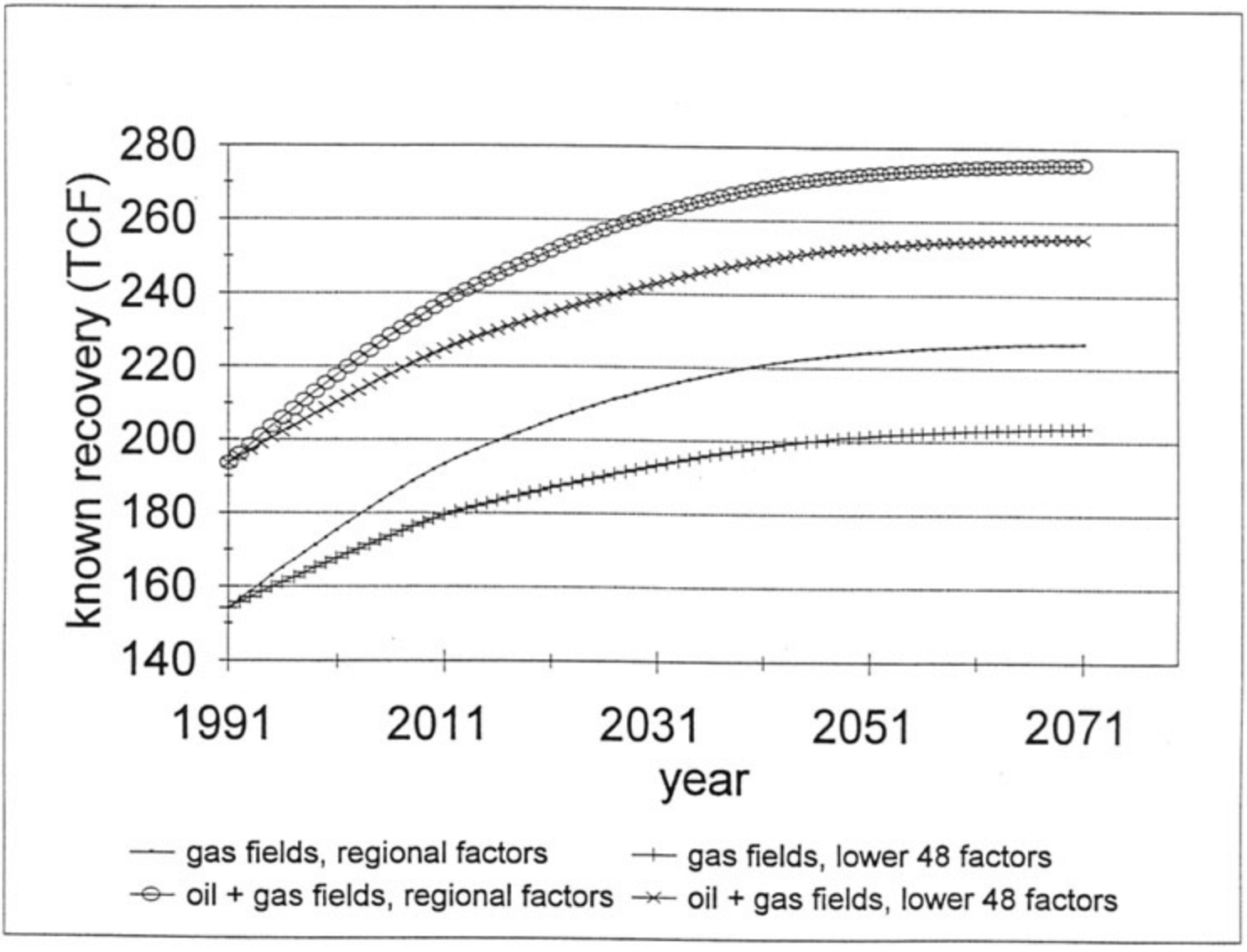


Figure 15. Region 7 Midcontinent - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

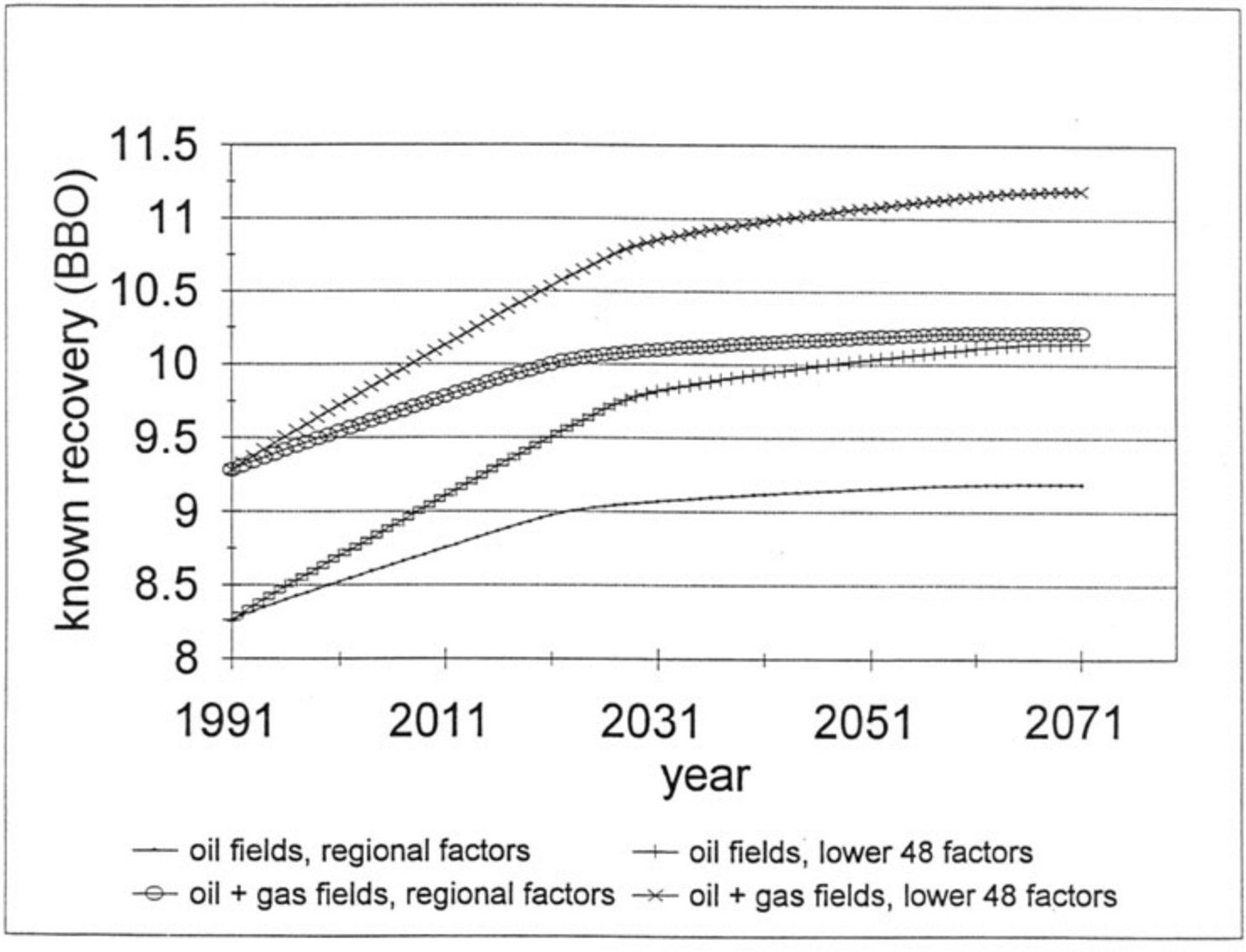


Figure 16. Region 8 Eastern - Growth in known oil recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of oil growth after 1991 for pre-1992 fields. The projections of known oil recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. Lower 48 is limited to onshore and state offshore.

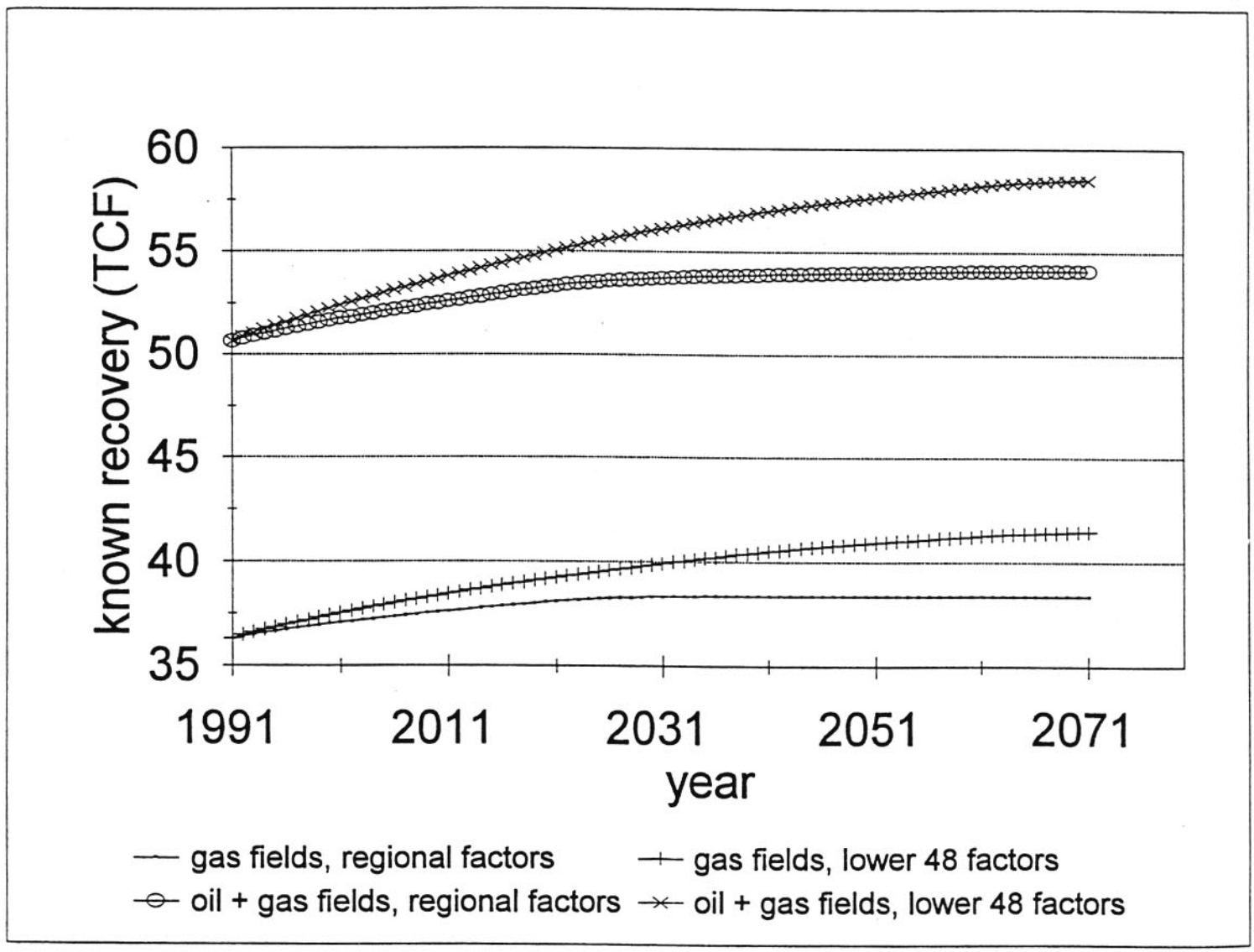


Figure 17. Region 8 Eastern - Growth in known gas recovery. The difference between regional and Lower 48 growth functions is illustrated in four projections of growth after 1991 for pre-1992 fields. The projections of known wet-gas recovery from pre-1992 fields start from 1991 estimates of known recovery. Known recovery is cumulative production plus proved reserves. NA. is non-associated wet gas and AD. is associated dissolved wet gas. Lower 48 is limited to onshore and state offshore.

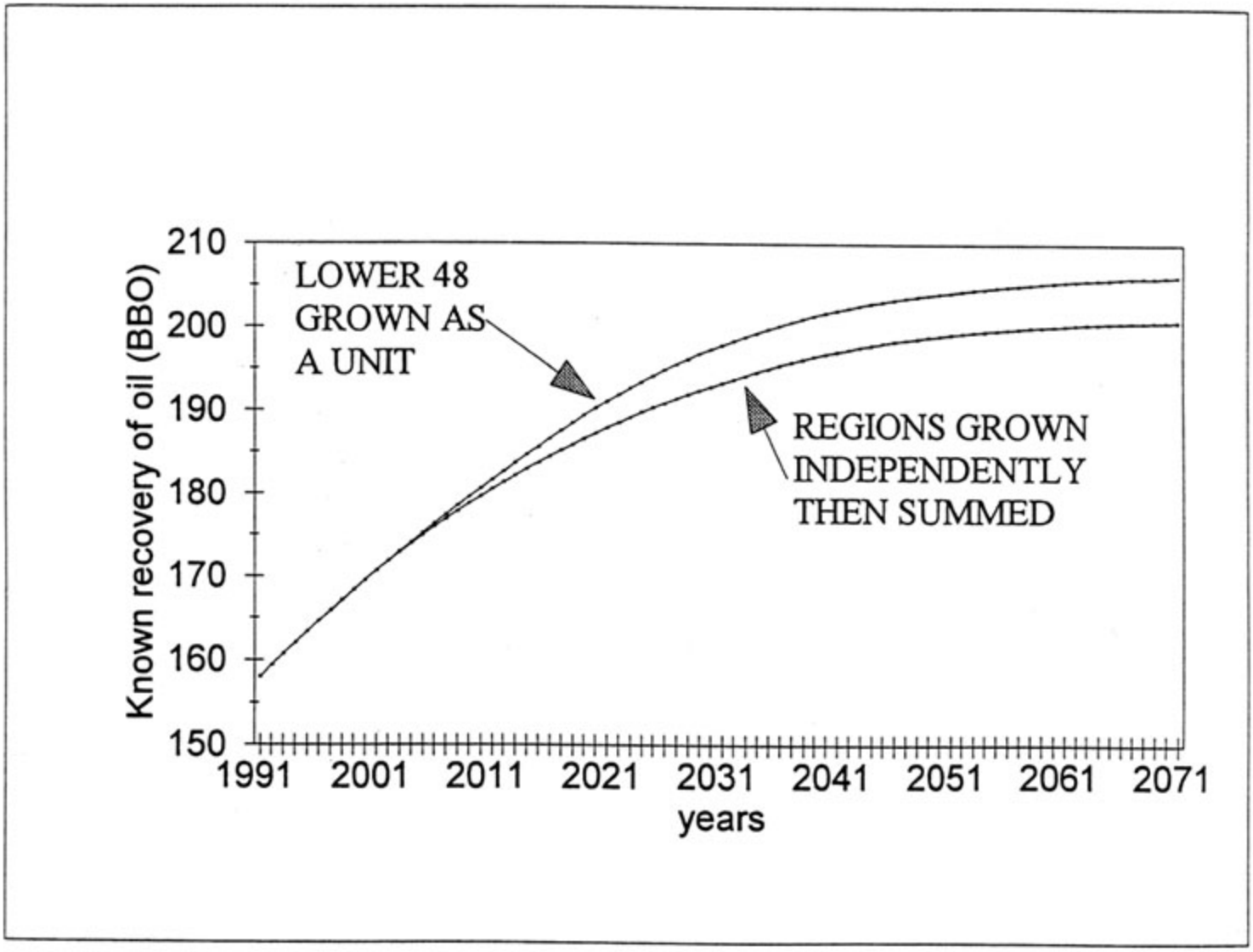


Figure 18. Lower 48 States (excluding Federal offshore). Comparison of growth of known recovery of oil in all fields discovered prior to 1992 estimated two different ways. The comparison starts with 1991 estimates of known recovery. In the upper curve the Lower 48 States was treated as a unit. In the lower curve the 7 regions were each grown independently and those results were summed.

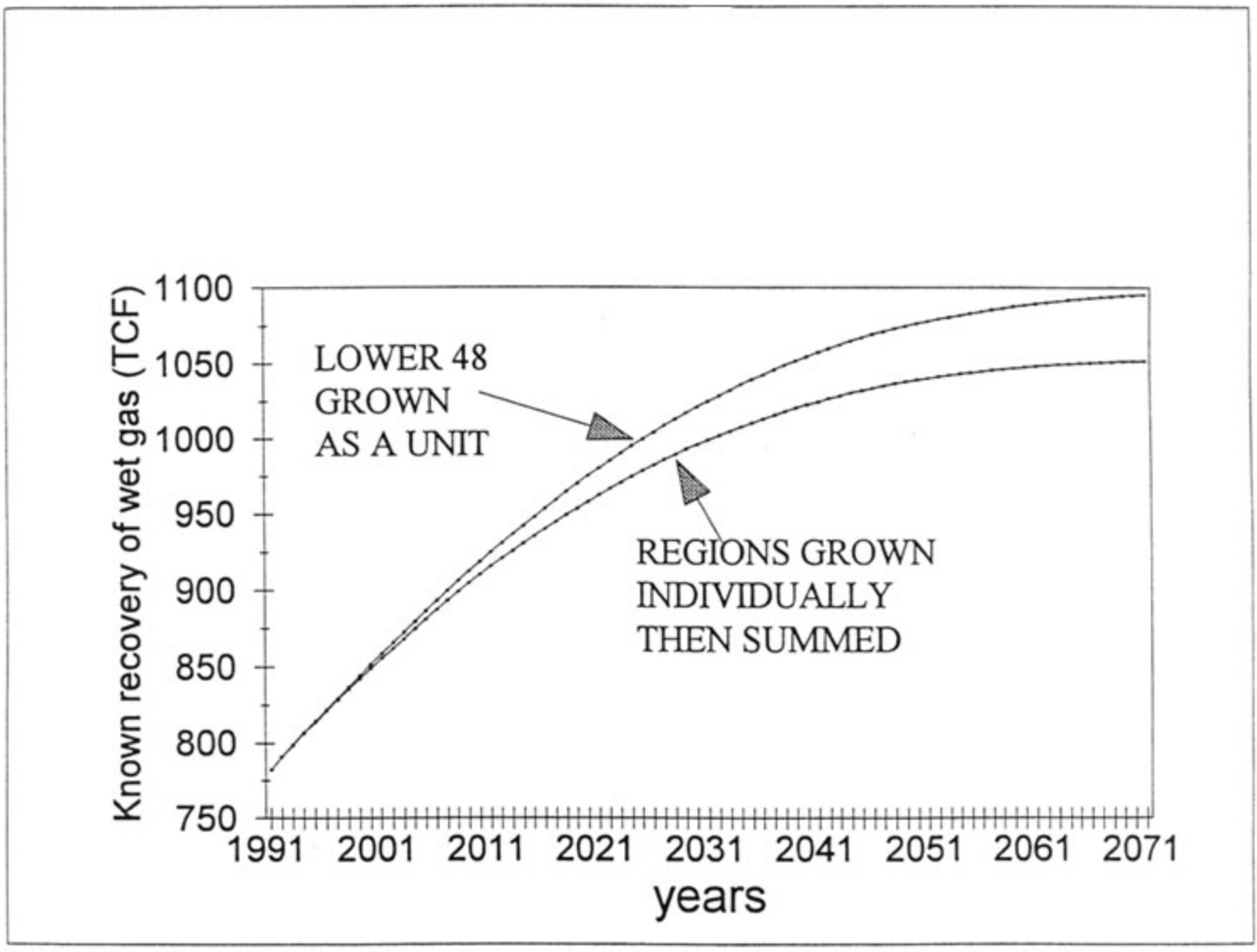


Figure 19. Lower 48 States. States (excluding Federal offshore). Comparison of growth of known recovery of wet gas in all fields discovered prior to 1992 estimated two different ways. The comparison starts with 1991 estimates of known recovery. In the upper curve the Lower 48 States was treated as a unit. In the lower curve the 7 regions were each grown independently and those results were summed.

Click Here to Return